

# DEVONIAN AND ?LATE SILURIAN PALAEOONTOLOGY OF THE WINNEKE RESERVOIR SITE, CHRISTMAS HILLS, VICTORIA

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**ABSTRACT:** During construction of the Winneke Reservoir a number of Late Silurian or Early Devonian fossils were discovered in the Dargile-Humevale Formation transition beds and as all the sites are now underwater, description of these fossils is presented as most are first records for Australia. They include a species of scyphomedusoid, *Conularia comriei* sp. nov. the trilobites *Odontochile formosa* Gill 1948, *Reedops* sp. nov. and a questionable record of the Subfamily Tropidocoryphinae, the crinoids *Dendrocrinus saundersi* sp. nov., *Codiocrinus rarus* sp. nov., *Kooptoonocrinus nutti* gen. et sp. nov., and a new genus of Dimerocrinitidae, the solutan carpoid *Rutroclypeus junori* (Withers 1933) and the ophiuroids *Urosoma glabridiscus* Talent 1965 and *Mausoleaster sugarloafensis* gen. et sp. nov. Apart from the new genera it is the first Australian record for *Reedops*, *Codiocrinus* and *Dendrocrinus*.

When the Winneke Reservoir filled in 1981 the area drowned was underlain by Upper Silurian and/or Early Devonian sediments of the Dargile and Humevale Formations. Considerable earthworks including quarrying for rock fill during construction of the dam afforded excellent exposures of fresh rock. Fossils proved to be relatively rare in the exposed sediments but are nevertheless quite significant in several respects.

One site NMVPL261 yielded enormous numbers of the large dalmanitinid trilobite *Odontochile formosa* but only five specimens of *Reedops*, one of the carpoid *Rutroclypeus junori* and one of the ophiuroid *Mausoleaster sugarloafensis*. NMVPL260 on the other hand produced large numbers of brachiopods but only a single echinoderm. Taken overall the seven echinoderm species are known from only 10 specimens whereas one trilobite species is known from hundreds. The lithologies of the collecting localities are not vastly different, suggesting that conditions were similar. Such radically different faunas from similar sites, thought to be relatively close together temporally, suggest that they are not natural assemblages. Moreover, articulated trilobites and whole echinoderms suggest burial of live animals. Taken together these two indications suggest some sort of mud flow deposition.

The fauna itself provides several new generic records for Australia particularly among the echinoderms, new information on *Rutroclypeus* that shows its stèle to have a structure much more in keeping with other solutan carpoids than was previously acknowledged, a firmer understanding of the species *Odontochile formosa*, and the first Australian record of *Reedops*.

All material is housed in the Palaeontological Collections of the National Museum of Victoria (prefixed NMVP) and localities appear on the Palaeontological Locality register of the same institution (prefixed NMVPL).

## LOCALITIES

The Winneke Reservoir is situated 33 km northeast of Melbourne, just south of Christmas Hills on the Wat-

son's Creek to Yarra Glen Road (Fig. 1, inset). Fossils were recovered between 1979 and 1981 from the two now-flooded localities NMVPL260 & 261 (Fig. 1).

NMVPL261 was a low cutting for an access track on the right bank of the stream gully not far above the stream level; Yan Yean 1:63 360 geological sheet, grid reference 500298. Fossil list:

Trilobita	<i>Odontochile formosa</i> Gill 1948 <i>Reedops</i> sp. nov. Tropidocoryphinae? gen. et sp. indet.
Mollusca	straight nautiloid indet.
Coelenterata	solitary Rugosa (moulds only) <i>Conularia comriei</i> sp. nov.
Echinodermata	<i>Rutroclypeus junori</i> Withers 1933 <i>Mausoleaster sugarloafensis</i> gen. et sp. nov.
Brachiopoda	<i>Notoparmella plentiensis</i> Garratt 1980

NMVPL260 was in a small cutting for a track that ran up the side of the ridge from the main creek gully; Yan Yean 1:63 360 geological sheet, grid reference 501295. Fossil list:

Echinodermata	<i>Codiocrinus rarus</i> sp. nov.
Brachiopoda	<i>Notoparmella plentiensis</i> Garratt 1980 <i>Notanoplia panifica</i> Garratt 1980

Site geologists Ray Saunders and Wayne Regan made a collection during initial excavations at a site now buried beneath the right abutment of the main dam wall, which is situated at grid reference 493293 on the Yan Yean 1:63 360 geological sheet. Fossil list:

Echinodermata	<i>Dendrocrinus saundersi</i> sp. nov. <i>Mausoleaster sugarloafensis</i> gen. et sp. nov. <i>Urosoma glabridiscus</i> Talent 1965
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The only other fossils described are on a single slab of siltstone that was removed from a quarry at the dam site to a distant location. At the time of dumping Mr.

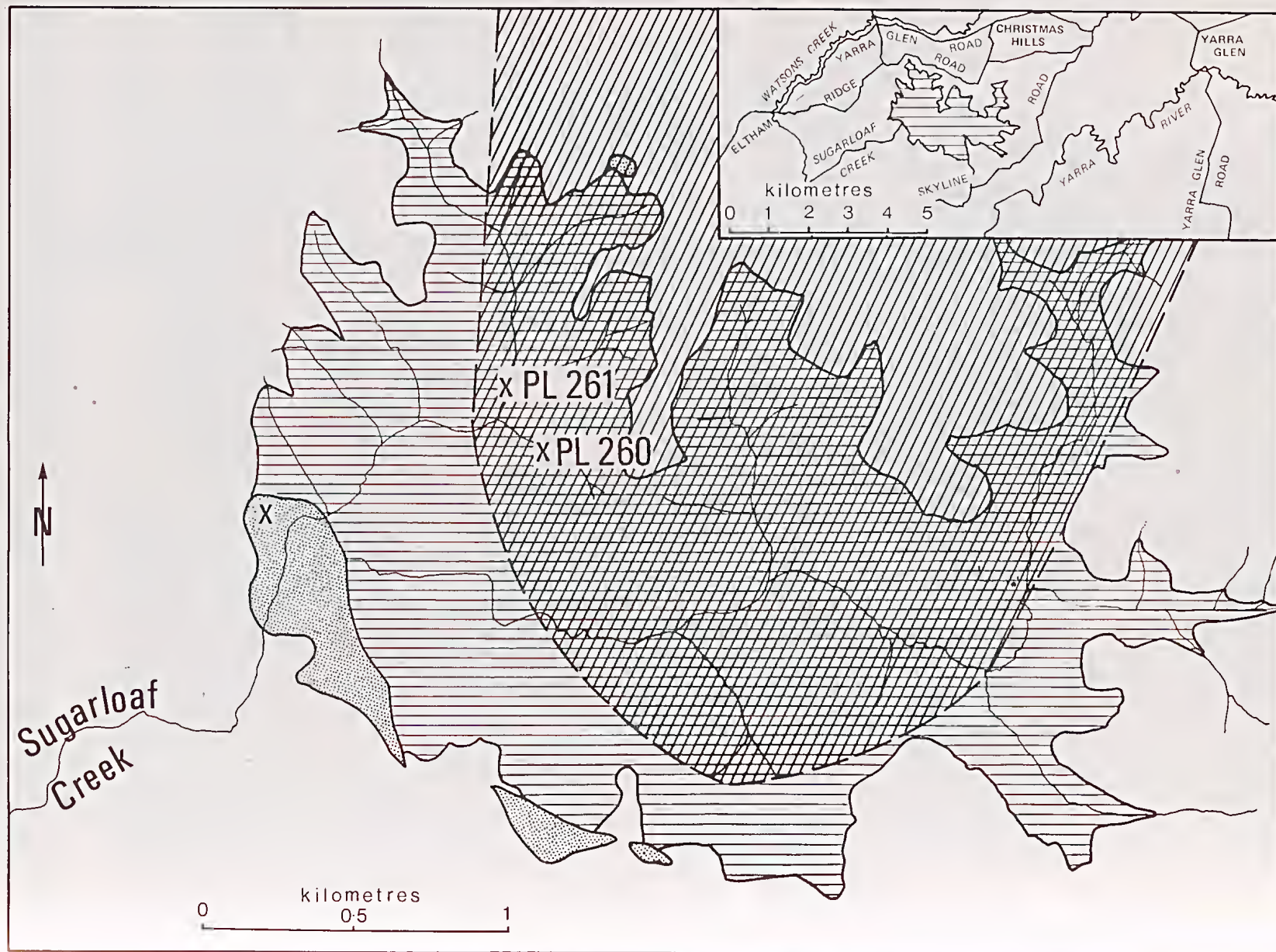


Fig. 1—Locality map. The dam walls are stippled and the flooded area is horizontally lined (in the inset also). The Hume scale bar is



Ron Nutt split the rock exposing two crinoids identified as *Kooptoonocrinus nutti* gen. et sp. nov. and *Dimerocrinitidae* gen. et sp. nov.; as a consequence the exact site and horizon of the specimens are not certain. Fossil fragments were noted at a number of other localities within the dam site but no specimens were complete enough or well enough preserved for identification.

## STRATIGRAPHY AND AGE

On the Yan Yean 1:63 360 geological map the strata at the site of the main dam wall are assigned to the Dargile Formation of Ludlovian age. None of the fossils from the site contradict this age, and in fact one of the species, *Urosoma glabridiscus* Talent 1965, was originally described from the type area of the Dargile Formation in the Heathcote district, where it occurs at a similar stratigraphic level as early Ludlow graptolites (VandenBerg & Garratt 1976). Localities NMVPL260 and 261 lie close together stratigraphically much higher in the sequence than the site of the dam, but there has been some confusion as to their exact age and horizon. On the Yan Yean 1:63 360 geological map they are situated just above the base of the Humevale Formation which is shown as corresponding with the Silurian-Devonian boundary, although in the Clonbinane area some 45 km to the northwest the Humevale Formation is now known to extend down into the Ludlow (Garratt 1978). Garratt (1980) assigned the strata at NMVPL260 to the upper part of the Dargile Formation and suggested a late Ludlow-Pridolian age, based on the presumed ages of the strata at other localities in the Melbourne Trough where *Notoparniella plentiensis* and *Notanoplia panifica* are known to occur. However, the fossils we describe from NMVPL261 suggest that the age may be somewhat younger than this. *Odontochile formosa*, *Conularia comriei* and *Rutroclipeus junori* all occur quite high in the Humevale Formation at Kinglake West, where the sediments are of Early Devonian age. Of course these species may be long-ranging, but more compelling evidence for an Early Devonian age is provided by *Reedops* sp. nov. The oldest known species of this genus is *R. deckeri* Delo 1935 from the Gedinnian of Oklahoma, and the next oldest species are all early Siegenian (Campbell 1977).

## SYSTEMATIC PALAEOLOGY

Phylum COELENTERATA (P.A.J.)

Class SCYPHOZOA

Order CONULARIIDA Miller & Gurley 1896

Family CONULARIIDAE Walcott 1886

Geus *Conularia* Sowerby 1821

*Conularia comriei* sp. nov.

Fig. 2

ETYMOLOGY: The species is named for Mr. Michael

Comrie, who, as site manager for the reservoir project, greatly facilitated our collecting.

HOLOTYPE: The external mould NMVP74247 of an incomplete specimen from NMVPL261.

PARATYPES: NMVP79546 from a small quarry on the Whittlesea road 3.2 km from Kinglake West, and NMVP73828 from NMVPL261.

DESCRIPTION: The individual was very large (80 mm long and incomplete); regular transverse ridges (21 per 10 mm) bear prominent tubercles which are not continuous across the interridge spaces but do line up in longitudinal regular columns; the transverse ridges are continuous across marked corner depressions; tubercles on the transverse ridges become quite crowded together in the corner depressions and become elongate off the ridges into the interridge spaces which they cross completely at many levels. On the faces, the transverse ridges very rarely bifurcate (3 examples known, see Fig. 2A, B, D).

REMARKS: The holotype is larger than almost all described conulariids. The state of preservation with the two surfaces crushed against each other and a great deal of fragmentation suggests that the wall was relatively soft and, unlike that of most other conulariids, had little mechanical strength. Towards the apical end (i.e., down in Fig. 2C) are two long tapering scimitar-shaped objects that project from inside the ruptured individual. Such objects are common throughout the Silurian and Devonian of the Melbourne Trough but are generally not associated with conulariids. If they are not part of the conulariid it is difficult to imagine how they became lodged where they are in what are apparently rapidly buried fossils. It may be that they are part of an organism that scavenged on and caused the extensive fragmentation of walls evident at that end of the conulariid. This association is ambiguous but may hold a clue to the identity of the relatively common scimitar-shaped fossils.

The bifurcations (or discontinuities) of certain transverse ridges forming a loop in one case (Fig. 2D) are rare in conulariids outside the corners and midlines. Their significance is not apparent as functional interpretation of conulariids has not yet been accomplished.

This species is readily distinguished from *C. ornaticissima* Chapman 1903 (see Talent 1965) by its fewer ridges per unit length and by its size; from *C. chapmani* Fletcher 1938 by its discontinuous longitudinal columns, size and occasional ridge bifurcations; from *C. sowerbyi* de Verneuil 1845 by its size, by its tubercles not being so close packed, and by its tubercles being in longitudinal alignment. It should be noted in passing that neither of the Victorian specimens attributed to *C. sowerbyi* by Chapman (1903) belongs to *C. chapmani* as suggested by Fletcher (1938); they each represent separate species. Talent's (1965) *Conularia* n. sp. appears to be conspecific with *C. comriei* but its very fragmentary nature precludes certain identification.

Phylum ARTHROPODA (D.J.H.)

Class TRILOBITA



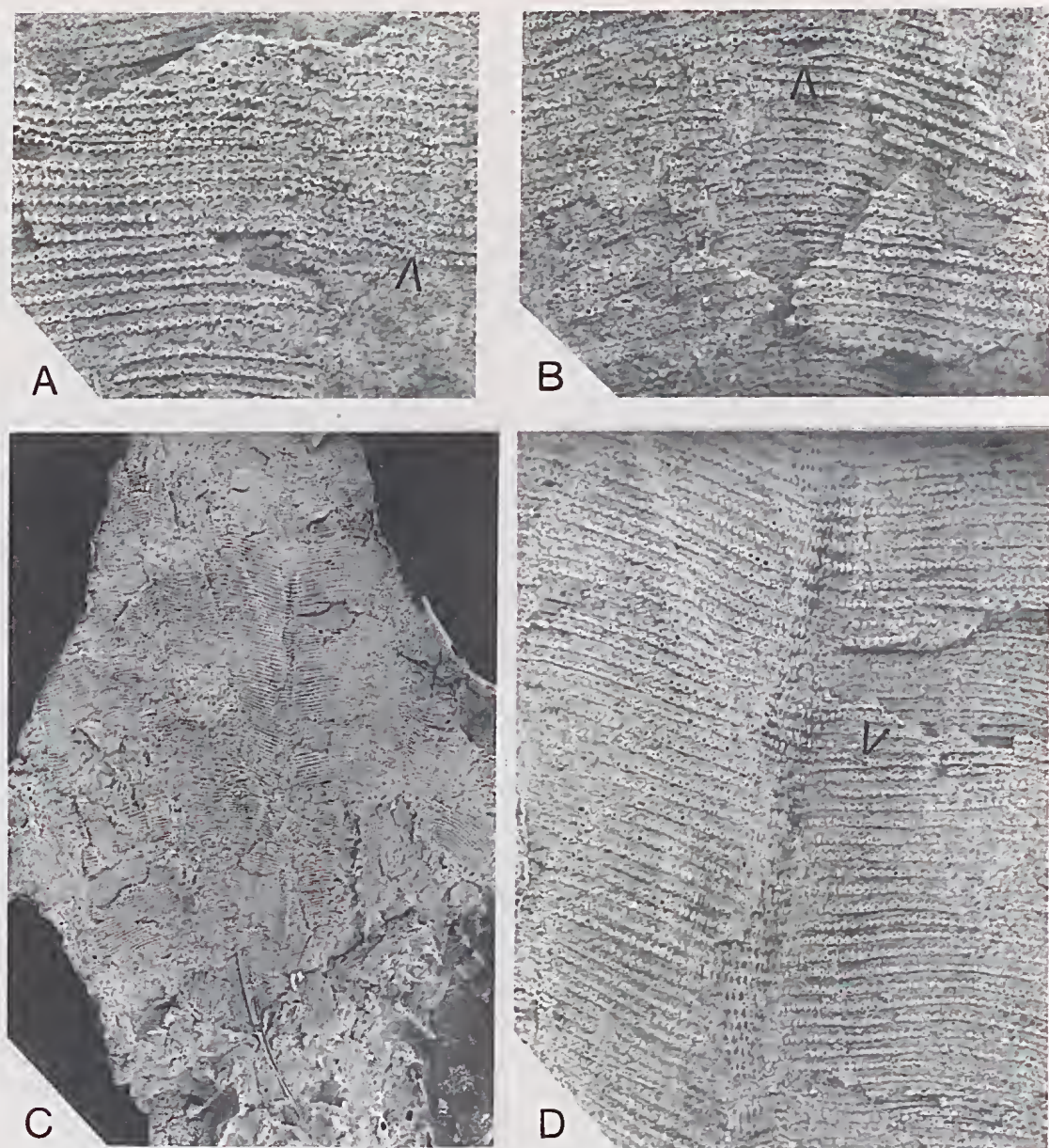


Fig. 2—*Conularia comriei* sp. nov. NMVP74247. A, B, D, enlargements of latex cast of various parts of specimen fully illustrated in C; arrows indicate bifurcations in the transverse ridges, A, B,  $\times 6$ ; D,  $\times 4$ ; C,  $\times 1$ .

Order PROETIDA Fortey & Owens 1975

Superfamily PROETACEA Salter 1864

Family PROETIDAE Salter 1864

Subfamily TROPIDOCORYPHINAE Pribyl 1946

*Tropidocoryphinae?* gen. et sp. indet.

Fig. 3I

MATERIAL: An incomplete thorax and pygidium from NMVPL261.

REMARKS: The most distinctive features of the pygidium are the narrow axis (the axial rings themselves are not preserved); the pleural furrows that are sharply impressed, except for the posterior two, and have steep anterior slopes and gentle posterior slopes; the non-existent interpleural furrows; the anterior pleural bands that are elevated above the posterior bands, especially distally; the very narrow border on the pleurae; and the ornament of fine striations. The specimen is tentatively assigned to the Tropidocoryphinae because the structure of the pygidial pleurae is similar to the imbricate type found in that subfamily.



## Order PHACOPIDA Salter 1864

## Suborder PHACOPINA Struve in Moore 1959

## Superfamily PHACOPACEA Hawle &amp; Corda 1847

## Family PHACOPIDAE Hawle &amp; Corda 1847

## Subfamily PHACOPINAE Hawle &amp; Corda 1847

Genus *Reedops* R. & E. Richter 1925

TYPE SPECIES (by original designation): *Phacops bronni* Barrande 1846 from the Dvorce-Prokop Limestone (Pragian) at Damil near Tetín, Czechoslovakia.

REMARKS: This genus has been discussed recently by Campbell (1977) and Chluřác (1977).

*Reedops* sp. nov.

## Fig. 3A-H

MATERIAL: Two incomplete cephalae, an incomplete thorax, and two thoraces with pygidia attached, from NMVPL261.

DESCRIPTION: Glabella very incomplete on available cephalae. Occipital ring with well-defined lateral lobes 0.5 times as long (exsag.) as medial portion of ring. Lateral nodes of 1p lobe distinctly larger than occipital lobes; 1p furrow directed posteromedially as far as inner edge of node where it shallows abruptly and is deflected forwards. Sides of glabella diverge at approximately 60° in front of 1p furrow; 2p and 3p furrows very weak, 2p apparently situated level with posterior edge of eye, 3p with convex-forward inner part lying opposite midlength of eye and outer part converging gently with axial furrow at front of palpebral lobe. Cheek is gently convex in transverse and lateral profiles and slopes steeply anterolaterally. Eye situated well forward and low on cheek, with ventral margin lying in lateral border furrow; distance of eye from junction of lateral and posterior border furrows almost equal to its own length. Palpebral lobe relatively narrow, with outer rim defined by shallow marginal furrow; palpebral furrow only weakly curved and continuous posteriorly with a deeper postocular furrow. Visual surface composed of at least 21 dorsoventral lens files of up to 13 lenses each; lenses very closely spaced so that each is almost in contact with its neighbours, even at top of files. Posterior border well-rounded (exsag.) proximally, expanding abaxially beyond the fulcrum and becoming more flattened; posterior border furrow deep and sharp. Lateral border steeply inclined, narrowing slightly from genal angle to posterior edge of eye; lateral border furrow decreases in depth where it is deflected outwards around base of eye. Entire dorsal surface of cephalon (except in furrows) covered with coarse granules ranging in diameter from 0.2 mm to less than 0.1 mm. Finest granules on glabella are just above preglabellar furrow, and densest concentration is on upper surface of frontal lobe. On cheek, granules decrease in size and density adjacent to axial furrow and on lateral border beneath eye; outer rim of palpebral lobe is densely covered with fine granules.

Lateral part of cephalic doublure carries a deep, weakly notched vincular furrow bounded on the inside by a prominent, sharp ridge that weakens opposite posterior edge of eye. Posteriorly, vincular furrow is deflected inwards across doublure towards distal end of posterior border furrow, and anteriorly it shallows abruptly beneath midlength of eye (the sharp line extending forward from this position in Fig. 3E is a crack). Medial part of doublure incompletely known, but fragments preserved show that anterior part of vincular furrow is long (sag., exsag.), weak and poorly defined, and carries normal ornament (Fig. 3H, arrowed). Ornament on doublure consists of granules that are smaller than those on dorsal surface, and that develop laterally into fine terrace lines on ridge along inside of vincular furrow. Inner, flattened part of doublure below this ridge is smooth.

Thoracic segments have strongly arched (tr.) axial rings with well-developed lateral nodes, and pleurae that rise gradually from axial furrow to fulcrum where they are turned strongly downwards. Axial rings contract slightly medially; in lateral profile they are rather flat-topped posteriorly but curve strongly downwards anteriorly into a deep, sharp articulating furrow that is slightly recessed below front of ring. Pleural furrows sharply impressed, with short, abrupt anterior slopes and more gradual posterior slopes; abaxially they curve forwards slightly onto articulating facets. On anterior segments, pleura curves gently forwards beyond fulcrum to broadly rounded tip; on posterior segments abaxial part of pleura is straighter and tip is almost orthogonally truncated. Doublure beneath pleural tips has well-developed panderian protuberances that are more oblique on anterior segments than posterior segments, and on posterior and distal margins of doublure are ventral projections that during enrollment overlap distal edge of succeeding segment (Fig. 3G). Granules on axial rings (excluding lateral nodes) and on downturned portion of pleurae beyond fulcrum are similar to those on glabella; on axial nodes and proximal portion of pleurae they are finer and less dense. Pleural doublure seems to be smooth.

Pygidium with 9 axial rings successively decreasing in convexity (sag., exsag.) posteriorly; small pseudo-articulating half rings present on rings 2 and 3, and tiny vestiges of them possibly remaining on rings 4 and 5. Ring furrows 1 to 4 deep and sharply impressed, but subsequent ones much shallower; all except posterior few ring furrows have transverse medial portions and lateral portions that are deflected forwards slightly and are weakly concave backwards. There are 7 or possibly 8 pleural furrows, the first four deep and sharp, and the last few very weak; there are 4 interpleural furrows that are shallow but distinct and do not extend as far abaxially as pleural furrows. Doublure consists of inner and outer bands that are concave in cross-section and separated by a marked change of slope that swings sharply inwards anteriorly across doublure. Inner band more steeply inclined than outer band, more concave (tr.) and wider, except posteriorly where it contracts



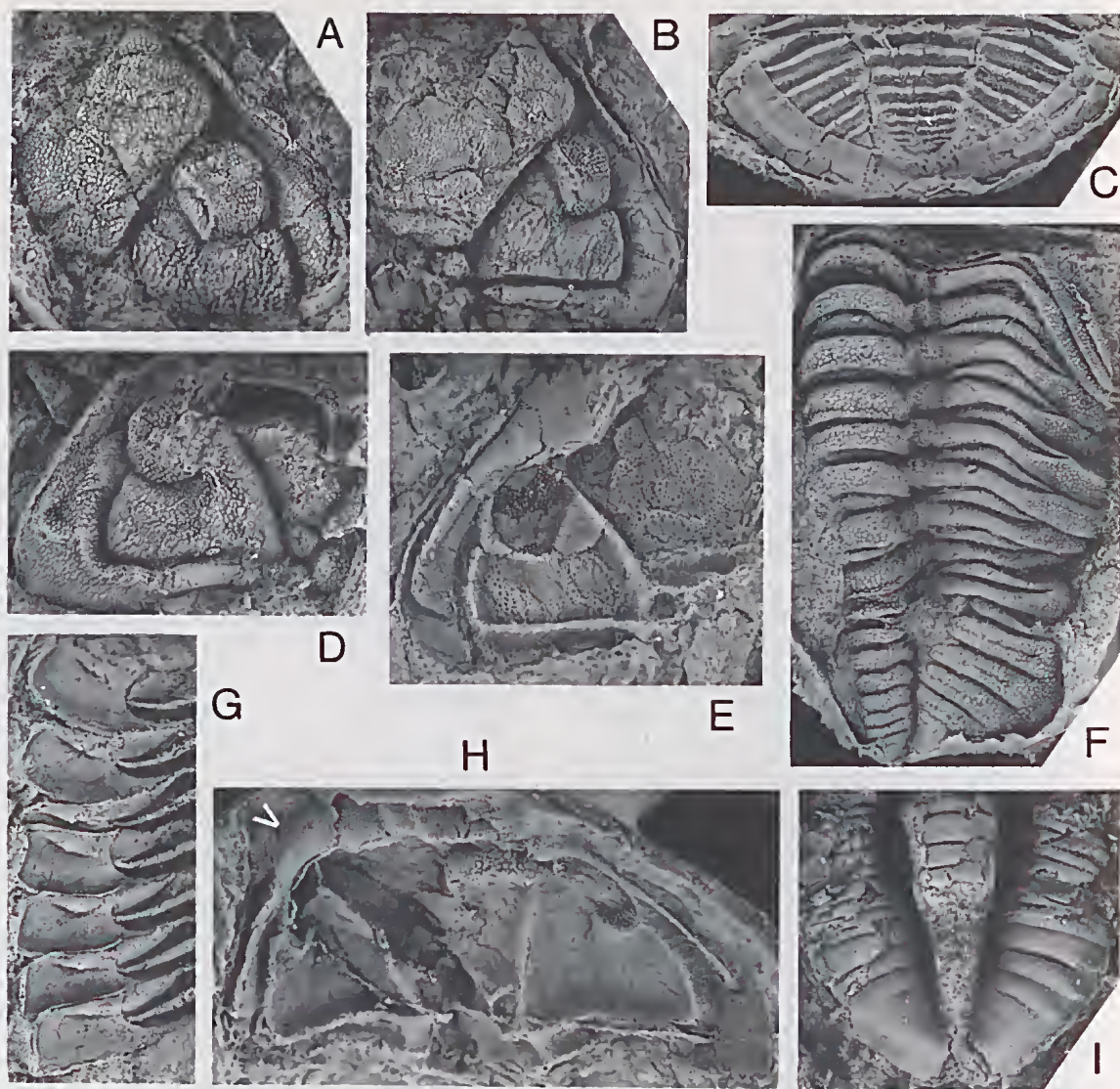


Fig. 3—A-H, *Reedops* sp. nov. All photographs except B are of latex casts. A, B, E, cephalon NMVP 82779,  $\times 2$ ; A, E, dorsolateral and ventral views; B, internal mould in dorsal view prior to preparation to expose external mould of doublure. C, pygidium of specimen with articulated thorax NMVP82780, ventral view,  $\times 1.8$ . D, H, cephalon NMVP82781; D, dorsolateral view,  $\times 2.5$ ; H, ventral view,  $\times 2.2$  (arrow indicates very weak anterior portion of vincular furrow; note that coarsely granulated object just behind doublure in centre of photograph is axial ring of a displaced thoracic segment). F, thorax and pygidium NMVP82782, dorsolateral view,  $\times 2.2$ . G, pleural tips of incomplete thorax NMVP82783, ventrolateral view,  $\times 2.5$  (anterior at top of photograph). I, *Tropidocoryphinae*? gen. et sp. indet. NMVP82784. Dorsal view of incomplete thorax and pygidium with exoskeleton preserved,  $\times 5.3$ .

gradually behind axis. Granules on dorsal surface of pygidium similar to those on glabella; granules on doublure much finer.

**REMARKS:** This species is clearly a member of *Reedops*, as shown by the rather uniform size of the granules over the entire exoskeleton, including the glabella; the relatively small, anteriorly placed eye that lies with its lower edge in the lateral border furrow; the very weak 2p and 3p furrows; and the vincular furrow that is deep

laterally but almost non-existent medially. In the coarseness of the exoskeletal granulation and the deep axial and pleural furrows on the pygidium, it is most similar to *R. deckeri* Delo 1935 from the Gedinian of Oklahoma (Campbell 1977). It differs from that species, however, in having eyes that are shorter (exsag.) but have a greater number of lenses per dorsoventral file, more weakly curved palpebral furrows, weaker furrows 2p and 3p, and a more poorly defined medial notch in the inner edge of the pygidial doublure.



Superfamily DALMANITACEA Vogdes 1890

Family DALMANITIDAE Vogdes 1890

Subfamily DALMANITINAE Vogdes 1890

Genus *Odontochile* Hawle & Corda 1847

TYPE SPECIES (ICZN Opinion 537 (1959)): *Asaphus hausmanni* Brongniart 1822 from the Dvorce-Prokop Limestone (Pragian), Prague district, Czechoslovakia.

*Odontochile formosa* Gill 1948

•Fig. 4

1948 *Odontochile formosa* Gill, p. 20, pl. 2, figs 1, 2.  
TYPE MATERIAL: Holotype Melbourne University Geology Department 882, internal mould of very large, almost complete dorsal exoskeleton from quarry approximately 2.8 km southwest of Kinglake West, Victoria (vicinity of locality W1 on map of Williams 1964, fig. 2); Humevale Formation (Early Devonian).

OTHER MATERIAL: Abundant remains of cephalo, thoraces, pygidia and hypostomes, mostly disarticulated and broken, from NMVPL261.

DESCRIPTION: Glabella expanding strongly forwards, widths at occipital ring, 3p lobe and frontal lobe approximately in ratio 1:1.5:2. Occipital ring well-rounded in lateral profile; in transverse profile it is strongly convex medially but becomes gently concave abaxially; no median occipital tubercle. Occipital furrow moderately deep medially, deflected gently backwards abaxially and becoming sharper as it turns down into occipital apodeme, finally curving laterally or even slightly forwards distally. Apodemal pits 1p and 2p directed slightly obliquely backwards abaxially, connected to axial furrow by distinct furrows 1p and 2p, and tending to be joined medially across glabella by shallow transverse furrows. 3p furrow deep, inner portion gradually increasing in length (exsag.) abaxially, outer portion expanded, more oblique than inner portion and more evenly curved in cross section (exsag.). Glabellar lobe 1p convex (tr.) medially but rising fairly steeply towards its anterolateral extremities; lobes 2p and 3p with inflated abaxial portions separated from gently convex (tr.) medial portions by broad and poorly defined longitudinal furrows. Frontal lobe approximately 1.6 times as wide as long, comprising more than half glabellar length and bearing a shallow longitudinal depression medially in its posterior half. Preglabellar furrow shallow abaxially and not impressed medially.

Palpebral lobe in most specimens situated further from sagittal axis posteriorly than anteriorly, distance from posterior border furrow slightly greater than length (exsag.) of posterior border; palpebral furrow shallowest in its posterior half. Eye with lenses arranged in approximately 50 dorsoventral lens files of up to 14 lenses each. Beneath eye is strongly impressed furrow, along outside of which on librigena is a prominent rounded (tr.) eye platform abutting lateral border furrow. Anterior branch of facial suture lies close to axial

and preglabellar furrows, diverging strongly from  $\gamma$  to  $\beta$ ; from  $\epsilon$ , posterior branch of suture runs just outside furrow beneath eye, before curving in a broad arc across cheek so that  $\omega$  lies opposite 2p lobe. Anterior border of cephalon decreases slightly in length (sag., exsag.) adaxially, median process absent. Lateral border with epiborder furrow more distinct on librigena than on fixigena; lateral border furrow shallow and well-rounded in cross section on librigena but sharper on fixigena. Posterior border expands distally to more than twice its proximal length (exsag.). Genal spine rather long and slender.

Granular ornamentation very sparse over most of dorsal surface of cephalon, but more dense on posterior and median parts of occipital ring, on central part of frontal lobe, on anterior border, and on palpebral lobe. (On the latter, granules increase in density towards the lateral margin but decrease in size.) Ornamentation not preserved on lateral and posterior borders and on dorsal surface of genal spine.

Hypostomal suture gently convex forwards. In front of hypostomal suture doublure gradually expands adaxially and is crossed by a deep arcuate depression running subparallel to cephalic margin; lateral to hypostomal suture doublure narrows slightly abaxially in front of eye and has a very low, upturned inner flange lying directly beneath eye platform. Posterior branch of facial suture runs backwards across doublure in a slight curve, meeting inner margin beneath distal end of posterior border furrow. Hypostome approximately as wide across anterior wings as long (sag.). Anterior border expands strongly towards anterior wings and anterior border furrow is very weak. Lateral margin curves sharply outwards from anterior wing to prominent shoulder lying well in front of hypostomal midlength. Behind shoulder, lateral border decreases in height and width, and lateral border furrow converges only weakly until level with medial part of middle furrow, where border becomes more flattened and expands gradually, and border furrow shallows and curves inwards. Posterior border has a shallow transverse, arcuate furrow running close to posterior margin, the latter deflected backwards medially and abaxially to three small spines; lateral border furrow contains a pair of indistinct depressions directly in front of lateral pair of spines. Outer portion of middle furrow meets lateral border furrow opposite shoulder and runs obliquely backwards to a pair of depressions lying just behind the hypostomal midlength; medial portion of middle furrow transverse, shallower than outer portion. Maculae not observed. Cephalic doublure (with possible exception of inner flange) and hypostome densely granulate.

Thorax composed of 11 segments. Axis increases in width (tr.) only weakly on first three segments and narrows just as weakly on last six segments; axial rings rather flattened (sag., exsag.), contracting slightly medially and tending to be orthogonally truncated by axial furrow distally. Pleural tips not well preserved on more anterior segments; posterior segments curve backwards distally to a sharp point. Doublure on



pleurae of posterior segments broad (tr.), inner edge subangular in outline (Fig. 4I, K); no trace of any pandermanian protuberance.

Pygidium approximately as wide as long (including mucro) in relatively undistorted specimens; lateral margin gently curved but overall outline is subtriangular rather than semielliptical. Axis 0.2 times as wide as pygidium anteriorly and narrowing uniformly backwards, composed of 17-19 or possibly 20 axial rings plus a terminal piece. Successively diminishing pseudo-articulating half rings are developed on at least rings 2-8, and in some specimens oblique muscle impressions are present on posterior half of rings lateral to pseudo-articulating half rings (Fig. 4B); ring furrows very short (exsag.) and sharp abaxially but longer sagittally and weak, even near front of axis. There are 13-14 pleural furrows that are evenly curved on more anterior segments but almost straight on posterior ones. Pleural furrows expand slightly distally and become shallower but extend virtually to pygidial margin; interpleural furrows terminate well inside margin. Mucro slender and extended horizontally backwards; its length measured from axial terminus is approximately half length of axis. Doublure gently convex (tr.), lacking a steeply inclined inner flange.

Granules on axis of thorax and pygidium are concentrated along posterior margins of rings and are virtually absent elsewhere. Abaxial part of pygidial pleurae and mucro are covered with a uniform granulation, but closer to pygidial axis and on thorax granules are present only along posterior edges of pleural bands. Doublure on pygidium and thoracic pleurae more densely granulated than dorsal exoskeleton.

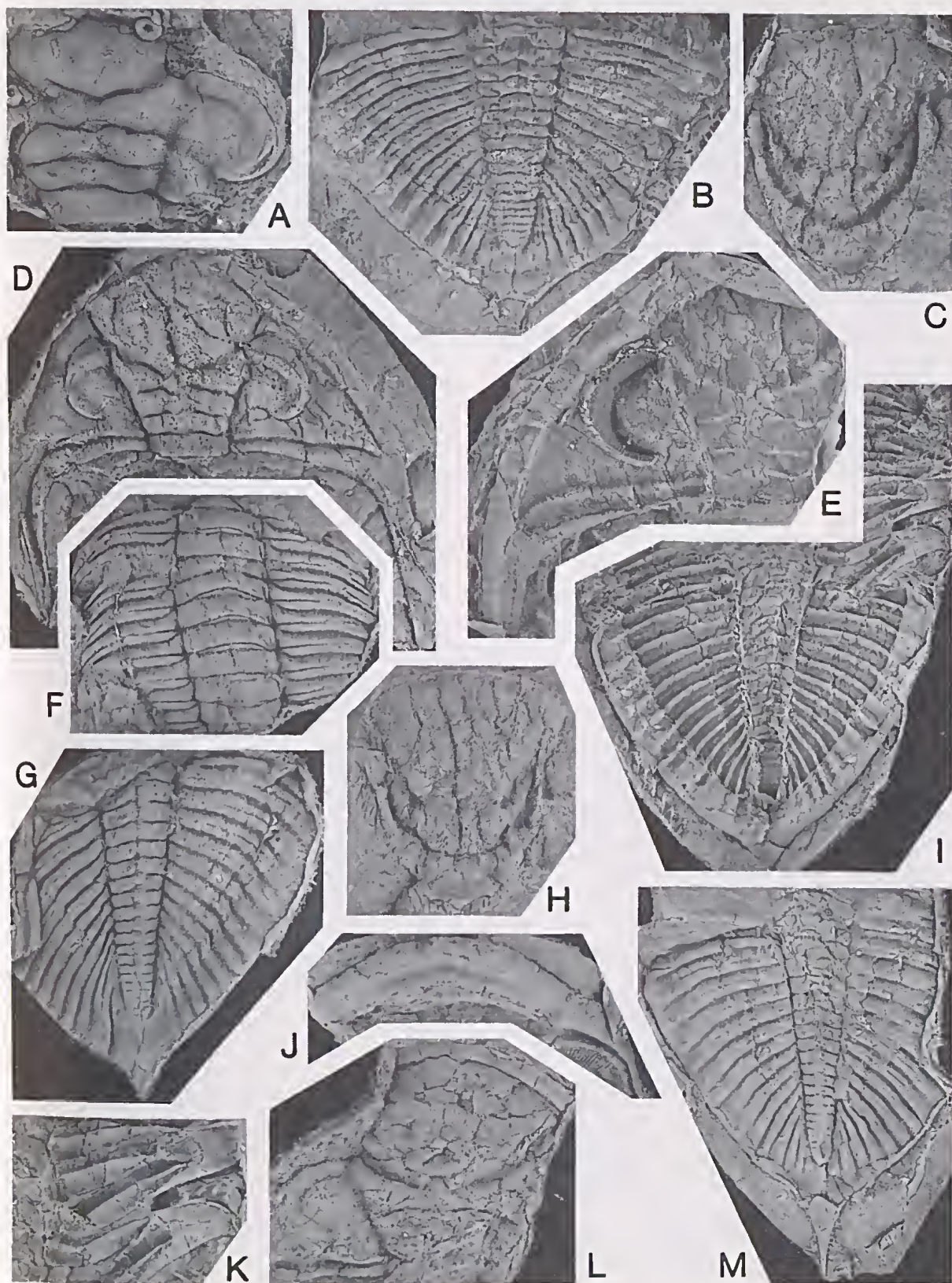
REMARKS: Gill's description of *O. formosa* was based only on the holotype, but there are a number of characters that cannot be determined from that specimen because it is an internal mould and is also broken in places. For example, there is no information on surface sculpture, the shape of the anterior cephalic border, or the length and shape of the mucro, and the eyes are very poorly preserved. No other specimens of *O. formosa* with these features preserved are known from the type locality. Gill (1948) also illustrated as *O. formosa* an internal mould of a cephalon belonging to a much smaller individual than the holotype and coming from a different locality in the same formation and area. Numerous additional specimens from this locality are available in the National Museum of Victoria collections, and they include external moulds of cephalon and pygidia as well as articulated exoskeletons. They differ from the holotype in a few respects, mainly in having a

more weakly inflated glabella, less distinct furrows 1p and 2p, and eyes that extend much closer to the posterior border furrow. However, I attribute the differences to the very much smaller size of these specimens. The specimens from the Winneke Reservoir site, which are of intermediate size, fall within the range of variation in these features, and in all other features closely resemble the specimens from both of the Kinglake West localities.

Three other dalmanitid species have been recorded from the Late Silurian to Early Devonian of southeastern Australia, but each is in need of revision as the published illustrations and descriptions are inadequate. *Dalmanites wandongensis* Gill 1948 from the Dargile Formation (Ludlovian) near Wandong, Victoria, is based on a cephalon and an internal mould of a pygidium differing from *O. formosa* in that glabellar lobes 2p and 3p are not as inflated abaxially and the axial furrow is weaker; the 3p furrow is shallower; there is no eye platform; the lateral cephalic border is narrower and more convex (tr.); there is almost no change in slope from the frontal glabellar lobe to the anterior border; the front of the cephalon is deflected downwards medially in anterior view; and there are only 14 axial rings and 11 pleural furrows in the pygidium. *Odontochile meridianus* (Etheridge & Mitchell 1895) from the late Ludlovian-Gedinnian of the Yass Basin, New South Wales, is distinguished from *O. formosa* by its much smaller eyes that do not extend as close to the lateral border furrow; a narrower lateral cephalic border; a pygidium with 15-16 axial rings and 11-12 pleural furrows that are deflected more strongly backwards distally; anterior pleural bands on the pygidium that are weaker, particularly abaxially; and a mucro that is relatively narrower and more convex (tr.) at its base and is connected to the axial terminus by a strong postaxial ridge. The anterior cephalic border is not preserved in any of the types, but specimens of *O. meridianus* in the National Museum of Victoria collections show that it differs from the anterior border of *O. formosa* in contracting slightly in front of the lateral part of the frontal lobe and expanding medially to form a very short (sag.), broad projection. The types of *Odontochile loomesi* (Mitchell 1919), also from the late Ludlovian-Gedinnian of the Yass Basin, appear to be indistinguishable from *O. formosa* but there is no information on surface sculpture as the specimens are all internal moulds, and the only cephalon known lacks the anterior border. When more material of *loomesi* becomes available it may be necessary to place *formosa* in synonymy with that species.

Fig. 4—*Odontochile formosa* Gill 1948. All photographs except H are of latex casts. A, cranium NMVP82785, dorsal view,  $\times 1.5$ . B, pygidium NMVP82786, dorsal view,  $\times 1$ . C, hypostome NMVP82787, ventral view,  $\times 1.25$ . D, cephalon NMVP82788, dorsal view,  $\times 0.9$ . E, cephalon NMVP82789, ventral view,  $\times 1.3$ . F, incomplete thorax NMVP82790, dorsal view,  $\times 1$ . G, pygidium NMVP82791, dorsal view,  $\times 1$ . H, internal mould of hypostome NMVP82792, ventral view,  $\times 1.4$ . I, K, M, pygidium and articulated thorax NMVP82793; I, M, ventral and dorsal views,  $\times 0.9$ ; K, enlargement of pleural tips on posterior thoracic segments in ventral view,  $\times 1.4$ . J, L, incomplete cephalon NMVP82794 in ventral and dorsal views,  $\times 1.25$ .







Phylum ECHINODERMATA (P.A.J.)

Class HOMIOISTELEA

Order SOLUTA Jaekel 1901

Family RUTROCLYPEIDAE Gill &amp; Caster 1960

Genus *Rutroclypeus* Withers 1933

TYPE SPECIES (by original designation): *Rutroclypeus junori* Withers 1933 from the Humevale Formation (Early Devonian) at Kinglake West, Victoria.

DIAGNOSIS: As given by Gill and Caster (1960) but the emphasis on flattened theca and proximal stele should be removed until proven.

REMARKS: The specimen described below may be used to argue that the proximal stele was not flattened as described by Gill and Caster (1960) and suggests other alternative interpretations for various parts of the stele. A closer correspondence with other solutan steles is interpreted (see Remarks on the species, below).

*Rutroclypeus junori* Withers 1933

Fig. 5, 6

1933 *Rutroclypeus junori* Withers, p. 18, pl. 5, figs 1, 2.1960 *Rutroclypeus junori* Withers; Gill & Caster, p. 30, pl. 1, figs 1-3, pl. 2, figs 2, 3.1967 *Rutroclypeus junori* Withers; Caster, p. S616.1982 *Rutroclypeus junori* Withers; Jell & Holloway, p. 42, fig. A.

HOLOTYPE: NMVP13681 from NMVPL229, Collins Quarry 2.4 km northwest of Kinglake West Post Office on the west bank of King Parrot Creek, Victoria. Humevale Formation—Early Devonian.

MATERIAL: One specimen, NMVP73811 from NMVPL 261

DIAGNOSIS (Gill & Caster 1960): "*Rutroclypeus* with spinose proximal stele having ten segments, the more distal of which may be deflected distally".

DESCRIPTION OF FIGURED SPECIMEN: The theca is round, 30 mm in diameter, consists of many polygonal plates reaching up to 4 mm in greatest dimension, and is preserved quite flat. Each plate has a short central spine. Around the thecal margin, plates curve back onto the other face very sharply and the median spine then appears to be marginal (as illustrated by Caster 1967, fig. 391-6). Marginal plates slightly dislodged on the right hand side (Fig. 5A) show the spines to be central with the marginal ridge linking the spines of contiguous plates.

The stele is relatively long (5.2 cm preserved) but is still incomplete. The proxistele consists of 10 circlets each of 4 plates arranged in four longitudinal series. Other longitudinal fractures of individual plates are irregular and when present may be near the axis or near

the outer margin and may be oblique, so they are clearly not following lines of weakness but were caused by compaction. The spines on the plates are much closer to the axis distally than they are near the theca, especially on the reverse side. The most proximal pair of obverse plates and the second and ninth plates in the left-hand obverse series lack spines. On the reverse the proximal pair of plates also lack spines. Between the centre line of the stele and the spine the posterior margin of each plate extends distally in a broad lobe beyond the more abaxial margin. On the obverse side there is no deflection of the distal plates.

Each plate in the proxistele has an anterior ledge on which the next anterior plate overlaps. Otherwise there is very little overlap of plates. The central suture on the reverse side becomes irregular to wavy distally with what appear to be small semicircular excavations (Fig. 5F, centre) in the plates of the last pair at their midlength. The mesistele consists of 1 plate on the obverse; the apparent sutures are fractures caused by compaction. On the right of the median stele (Fig. 5E, bottom right) is a spine that appears to be articulated. This suggests that all others on the proxistele may be articulated as well. On the reverse side the mesistele also appears to be a single plate as the fractures across it are highly irregular and due to compaction.

The distal stele (Figs 5D, 6) consists of an obverse and a reverse series of elongate plates that become progressively longer away from the theca. Transverse section of the distal stele is roughly diamond shaped with the margins of the reverse series apparently sitting just inside or against the margins of the obverse series. In lateral view plates of the obverse have an obtuse central elevation and their lowest point is at each end of the suture with the next plate in the series. Reverse plates that bridge the sutures between obverse plates apparently have a prominence to fit into the dip in the obverse lateral margin. All plates opposite the obtuse prominences have broadened lateral flanges upon which the obtuse prominences might fit but only the obverse plates are so situated in this specimen; reverse plates have all been displaced and lie inside the obverse series. Plates of the reverse series have a carinate median ridge, and are arranged so that there is one within the length of an obverse plate and that none of the junction sutures correspond to those of the obverse side. Consequently there are twice as many in the reverse series as in the obverse series. In the incomplete part of the distal stele preserved are 19 or 20 reverse plates but only nine and a half obverse plates.

An ornament of fine reticulate ridges, apparent on the proximal stele and thecal plates, is in broad terms radial away from the spine. On the distal stele the ornamentation is longitudinal, less reticulate and more granulate.

Fig. 5—*Rutroclypeus junori* Withers 1933, NMVP73811. All of latex casts. A, B, obverse and reverse,  $\times 1.7$  and  $\times 1.2$  respectively. C, D, lateral oblique view of distele showing plate arrangement,  $\times 8$ . E, obverse view of proxistele,  $\times 5.5$ . F, reverse view of proxistele—distele junction,  $\times 11$ . G, reverse view of proxistele,  $\times 6$ .





A



B



C



D



E



F



G

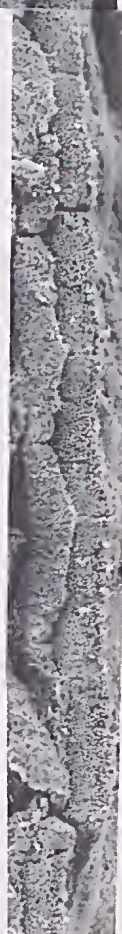






Fig. 6—Sketch of lateral view of plate arrangement in proximal part of distale of *Rutroclypeus junori*. Mesistele is enlarging plate at right. Obverse plates are upper series, reverse plates below. Drawn from Fig. 5D.

The arm is poorly preserved with only a single series of low wide brachial plates of the upper surface preserved. The inner side of the other series may be present beneath the upper series.

**REMARKS:** This specimen offers details on the thecal margin that uphold Caster's (1967) reinterpretation. Its greatest value is in the information it offers on the structure of the stele. The medial stele is seen to be formed by a single rather convex plate on each of the obverse and reverse sides. This in turn leads to the conclusion that the proximal stele had a subcircular or at least a transversely oval section and is flattened only by compaction. The common longitudinal fracture of plates is consistent with flattening an oval shape. Such a proximal stele is unlikely to have joined into a theca as flat as that suggested by Gill and Caster (1960, fig. 6) but such a section for the theca is not impossible. I cannot say what the thecal height was on available information. At the type locality of *Rutroclypeus junori* all other echinoderms with a sealed interior, including several with a considerable internal cavity such as blastoids, have been flattened without sediment filling the thecal cavity; plates have accommodated by fracture as in *Rutroclypeus* instead of by dislocation.

The structure of the distal stele is biserial and its cross-section is identical with that of *Dendrocystites sedgwicki* Barrande (see Caster 1967, fig. 372). Moreover the lateral view of the distal stele is very similar in these two genera in the way the plates fit together (Fig. 5D). This specimen and the recent note on *R. withersi* (Jell & Holloway 1982) suggest that a more detailed study of *Rutroclypeus* is warranted.

#### Class CRINOIDEA

#### Subclass CAMERATA

#### Order DIPLOBATHRIDA Moore & Laudon 1943

#### Suborder EUDIPLOBATHRIDA Ubaghs 1953

#### Superfamily DIMEROCRINITOIDEA Zittel 1879

#### Family DIMEROCRINITIDAE Zittel 1879

#### *Dimerocrinitidae* gen. et sp. nov.

#### Figs 7C-E, 8

**MATERIAL:** One individual, NMVP74246, found in a block of rock removed from the floor of the dam site during preflooding quarry works. It was noticed as the material was being dumped elsewhere so its original location and horizon are unknown. The holotype of *Kooptoonocrinus nutti* sp. nov. occurs on the same

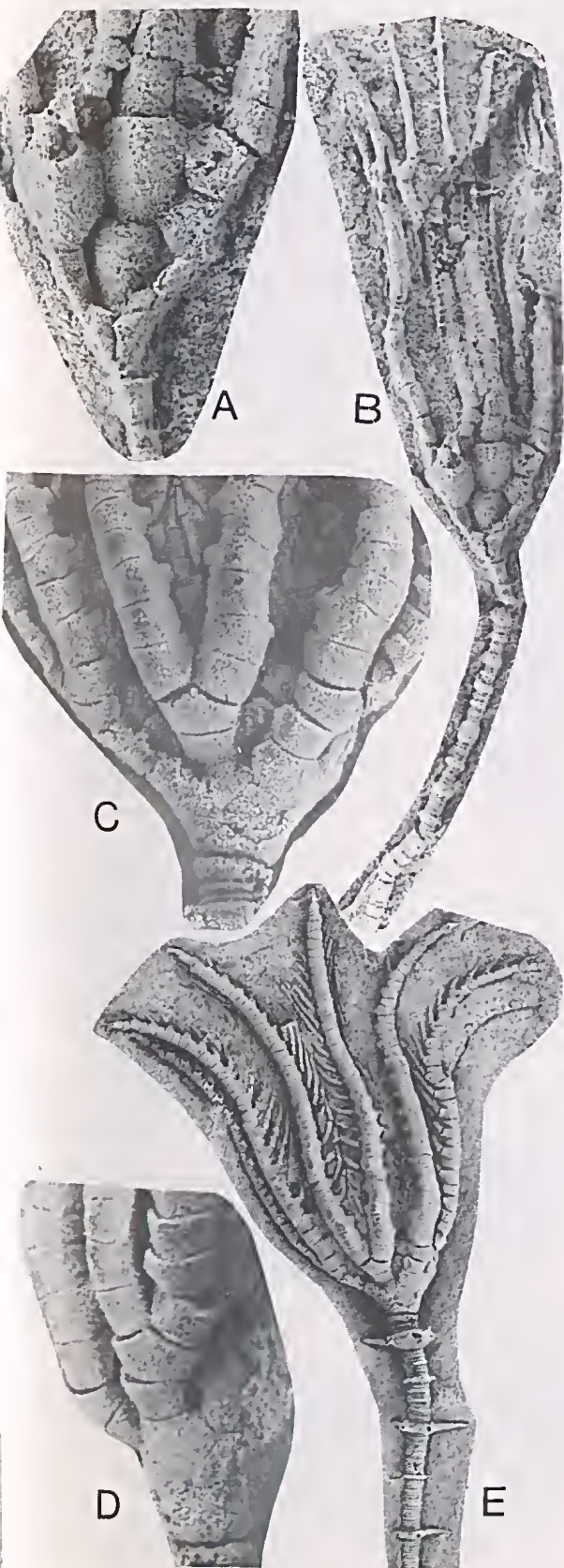
block of rock but whereas both part and counterpart of that specimen are available the counterpart of the dimerocrinitid fell from the face of the block, presumably at the time of splitting.

**DESCRIPTION:** Cup small for family, low, conical; infrabasals 5, visible laterally but quite low; basals 5, hexagonal, approximately twice height of infrabasals; CD basal slightly enlarged; radials 5, in contact with each other laterally except in posterior interray, with obtusely pointed lower margins; radial facet 0.8 of plate width, with broadly rounded outer margin, sloping out and down; primanal large, almost as large as CD basal upon which it sits, indirect contact with two posterior radials; further anal plates not known; interprimibrachs present but very deeply recessed between arms, one larger plate adjoining both first and second primibrach and supporting 2 smaller plates above. Arms dividing only once on primibrach 2 into 10 rami, uniserial, pinnulate, consisting of approximately 45 brachial plates per ramus; primibrachs fixed in theca; pinnules long, relatively stout, arising on alternate sides of consecutive brachials. Stem very slender, at least 25 cm long, circular in section, composed of cirriferous nodals separated by very low internodals varying from 3 to more than 20 per internode, and one or two non-cirriferous or weakly cirriferous nodals midway between the cirriferous ones or dividing the distance between strong nodals into three; distal part of stem with elongate irregular cirri apparently used in holding onto the substrate.

**REMARKS:** This specimen is assigned to the Camerata on the presence of interbrachial plates which are however not readily apparent. It is clear that these interbrachials are sutured to the sides of the brachial plates and that they are part of the tegmen, not simply fortuitously placed. Moreover, between the B and C rays may be seen the internal surface of a ramus from the opposite side of the theca (Fig. 7C, E) so that it would be very difficult for a long anal sac to be present without interfering with the mould of this ramus from the opposite side. On the other hand a short anal tube might not reach as high as the point where the opposite ramus appears or might be enveloped within the rami of the C and D rays. Such highly organised pinnulation is not known in inadunates of this age but is known in camerates.

As a dicyclic camerate with radial plates adjoining each other except in the posterior interray it may be referred to the Dimerocrinitoidea. Without a bulged posterior, with infrabasals visible laterally and with relatively low basals and infrabasals it may be excluded from all the families except the Dimerocrinitidae. This specimen does appear relatively close to *Ptychocrinus* Wachsmuth & Springer 1885 with its low infrabasals, depressed interprimibrachials and uniserial arms but it differs from that genus in having far less obtrusive interprimibrachials, in lacking medial ray ridges and anal ridge, in the relative sizes of cup plates and in the structure of the stem. It is part of the uniserial *Ptychocrinus* stock that apparently continued from the Ordovician and Lower Silurian (Witzke & Strimple 1981, Bret 1978)





*Ptychocrinus* through the Silurian and into the Devonian with *Macarocrinus* Jaekel 1895. Consequently another group should be added to the three already proposed in this family (Witzke & Strimple 1981); the fourth group should include uniserial members of the Dimerocrinitidae namely *Ptychocrinus*, *Macarocrinus* and the new genus described above. Although it is clearly not assignable to any existing genus this specimen is left in open nomenclature until details of its posterior interray and a better preserved cup are available.

#### Subclass INADUNATA

Order CLADIDA Moore & Laudon 1943

Suborder CYATHOCRININA Bather 1899

Superfamily CYATHOCRINITOIDEA Bassler 1938

Family EUSPIROCRINIDAE Bather 1980

#### Genus *Kooptonocrinus* nov.

ETYMOLOGY: From the Yarra aboriginal word *koopton* meaning one. It refers to the fact that both species of the genus are known from only one specimen.

TYPE SPECIES: *Kooptonocrinus nutti* sp. nov.

OTHER SPECIES INCLUDED: *Kooptonocrinus borealis* sp. nov. Its holotype is the specimen placed in *Ampheristocrinus typus* Hall 1879 by Springer (1926, pl. 31, fig. 1), from the Beech River Formation (Silurian) in Decatur County, Tennessee. It is housed in the National Museum of Natural History, Smithsonian Institution, Washington D.C., U.S.A.

DIAGNOSIS: Cup conical with strong ray ridges; infrabasals 5; anal X in radial circlet, large, supporting 1 to 3 sac plates; radianal pentagonal, below and left of C radial; arms slender, primibrachs 3 or 5 axillary, branching isotomously 4 times to produce a characteristic branching pattern; stem transversely rounded, composed of short alternating nodals and internodals.

REMARKS: Springer (1926) referred the type of *Kooptonocrinus borealis* to *Ampheristocrinus typus*, the type species of that genus, but whereas he stated that *Ampheristocrinus* was characterised by 3 infrabasals his own specimen is now known to have 5. Weller (1900) also considered the possession of only 3 infrabasals as a critical generic character. In view of the fact that important features of the arms and stem are not available from the type species of *Ampheristocrinus* I use the number of infrabasals to separate the new genus from *Ampheristocrinus*. Springer (1926) said he was uncertain of the number of infrabasals on his Tennessee specimen but Dr. P. M. Kier of the National Museum of Natural

Fig. 7—A, B, *Dendrocrinus saundersi* sp. nov. NMVP74239. All of latex casts. A, enlargement of theca in left posterior view,  $\times 7$ . B, left posterior view of latex cast of entire animal showing inner side of anterior arms,  $\times 2$ . C-E, Dimerocrinitidae gen. et sp. nov. NMVP74246. C, enlargement of theca and lower arms from left posterior,  $\times 6$ . D, posterior view of latex cast of theca,  $\times 6$ . E, upper stem and crown,  $\times 3$ .



History has recently determined that it has five infrabasals (written communication 17 June, 1982). It seems likely that Moore (1962) and Moore, Lane and Strimple (1978) used that specimen for their representation of 5 infrabasal plates in *Ampheristocrinus* also.

Although the family concept (Moore, Lane & Strimple 1978) appears to need some revision that is not attempted here. The new genus is assigned because it does not contradict the family concept and has some similarities with *Ampheristocrinus*. Its position in the phylogeny of the family is not clearly understood. *Kooptonocrinus borealis* sp. nov. is congeneric with the Australian specimen described below since they have the same thecal plate arrangement, narrow radial facets, branching pattern and stem structure. They may be distinguished by the Australian species having primibrach 5 (not 3) axillary and having the broad ridge running around its cup just beneath the radial facets.

### *Kooptonocrinus nutti* sp. nov.

Figs 8, 9A-D

**ETYMOLOGY:** The species is named for Mr. Ron Nutt of Healesville who found and donated the only specimen. **MATERIAL:** Only the holotype, NMVP74245 is known. It was found in the same block of rock as the new dimerocrinitid crinoid described above. The block comes from the dam site but no more precise locality is known.

**DIAGNOSIS:** Infrabasals 5; one anal tube plate on top of anal X; strong ridge transversely on radial plates just beneath radial facets encircling theca; primibrachs 5 axillary; arms branching isotomously at six different levels but each branch divides only four times; stem of nodals and internodals near theca, ossicles becoming uniform in height distally.

**DESCRIPTION:** Cup conical with slightly attenuated lower part, approximately 5 mm high. Infrabasals 5, pentagonal when viewed laterally, 1 mm high  $\times$  1.4 mm wide, with broadly obtuse central upper peak, ornamented with broad low but distinct ridges in "Y" form with 2 arms normal to the upper margins at their midpoints. Basals 5, hexagonal, 2 mm high  $\times$  1.5 mm wide, ornament continuing from infrabasals and forming a narrow cross so that the four ends of ridges are normal to plate margins at midpoints of sides. Radials 5, pentagonal, with ornament of two ridges continuing from basals to outer edge of radial facet and a further ridge running transversely across the plate where the vertical ridges meet. The transverse ridges form a circlet around the cup at a level just beneath the midheight of the plates. Articular facets 0.6 of width of plate, horseshoe shaped, sloping outwards. Anal X plate large, situated in radial circlet, pentagonal with transverse upper margin, ornamented the same as radial plates except that a further ridge rises vertically from the central confluence of the ridges and continues onto the first tube plate. Radial not fully preserved but apparently pentagonal, below and left of C radial. Anal X supporting one large anal tube and possibly one or more very small

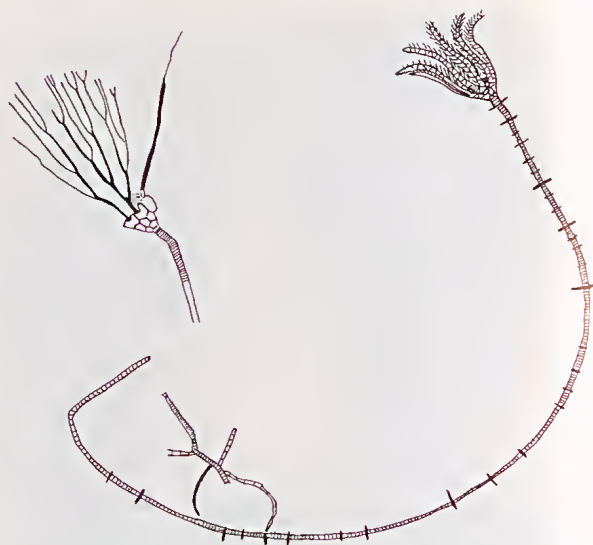


Fig. 8—Plan of slab with *Dimerocrinitidae* gen. et sp. nov. and *Kooptonocrinus nutti* sp. nov. showing length of stem and appendages.

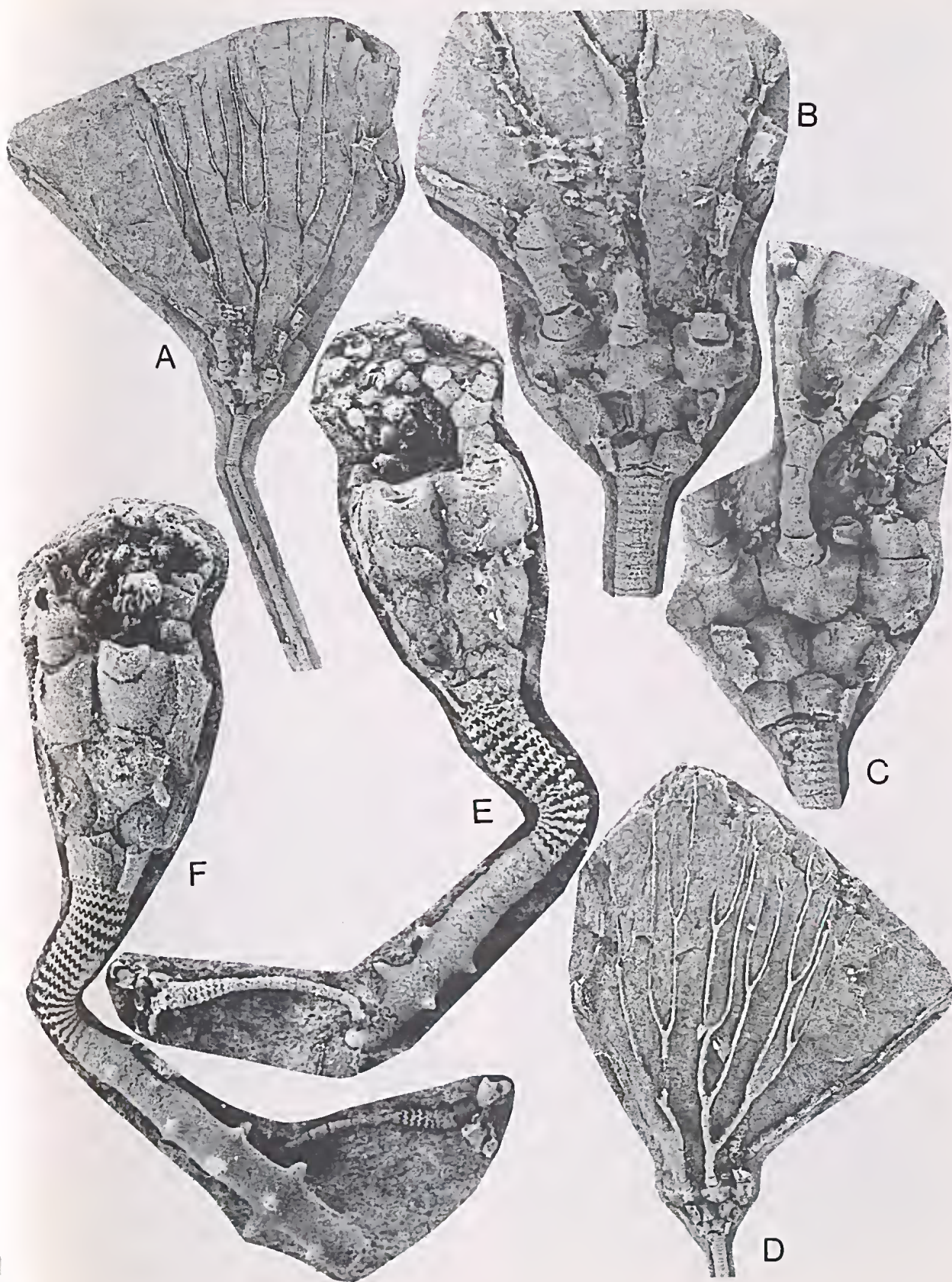
plates beside the large one, remainder of anal tube not preserved.

Arms very slender, long, branching isotomously; primibrach 5 axillary; first primibrach shorter than others. Secundibrach 5 axillary; all 10 secondary divisions at same height above cup. Tertibrach 7 axillary on two outer branches of each arm; tertibrach 12 axillary on two inner branches; outermost branches of each arm with quaternary brachial 12 axillary and two central branches of each arm with quaternary brachial 12 axillary. Branching regular and consequently at six different levels above cup but no arm divides more than 4 times; branching pattern apparently identical in all arms. Deep food groove on inner side of brachials with small triangular covering plates. Tips of arms 30 to 35 mm above cup.

Stem circular in section, very long with 60 mm preserved and still incomplete; composed of alternating long and short nodals and internodals for proximal 10 mm but thereafter formed of ossicles of uniform height. **REMARKS:** Although thecal plates have been slightly dislodged so affording good illustration of plate margins in most cases, the anal interray is on the level of a bedding plane (on right of Fig. 9C) so that it has suffered maximum dislocation with anal X on one side of the mould and radial on the other dislodged and partially overriding the C radial. Moreover, the mould of the anal

Fig. 9—A-D, *Kooptonocrinus nutti* sp. nov. NMVP74245. All of latex casts. A, B, right lateral view and enlargement of thecal area of same,  $\times 1.1$  and  $\times 6$ , respectively. C, D, left lateral view and enlargement of thecal area of same,  $\times 1.4$  and  $\times 6$ , respectively. E, F, *Codiocrinus rarus* sp. nov. lateral views of latexes from part and counterpart of same individual,  $\times 5$ . Large individual NMVP73810 and small individual attached to its stem NMVP73812.







X and the few succeeding anal plates is imperfect so interpretation of the anal plate arrangement is not absolutely clear.

Superfamily CODIACRINOIDEA Bather 1890

Family CODIACRINIDAE Bather 1890

Subfamily CODIACRININAE Bather 1890

Genus *Codiocrinus* Schultze 1867

1867 *Codiocrinus* Schultze, p. 143.

1887 *Codiocrinus* Schultze; Wachsmuth & Springer, p. 152.

1967 *Codiocrinus* Schultze; Lane, p. 11.

1973 *Elicrinus* Prokop, p. 221.

1978 *Codiocrinus* Schultze; Moore, Lane & Strimple, p. T596.

1978 *Elicrinus* Prokop; Moore, Lane & Strimple, p. T606.

TYPE SPECIES (by original designation): *Codiocrinus granulatus* Schultze 1867 from the Eifelian of Germany near Prüm.

DIAGNOSIS: Cup high, conical, infrabasals 3 (or perhaps 5) visible in side view; 5 large basals and 5 large radials all symmetrical; no anal plates in cup; radials with narrow articular facets; arms branching dichotomously on primibrachs 3; stem with circular section and prominent crenularium.

DISCUSSION: Although the type species of *Codiocrinus* has not been redescribed or reviewed in detail since 1867 its features are well established. *Elicrinus* Prokop 1973 (type species—*E. procerus* Prokop 1973 from the Pragian Dvorce-Prokop Limestones of Czechoslovakia) is equally well known from Prokop's (1973) original description but it was referred to "Family *Incertae sedis*" by him. Since 1973 the collative review of crinoid families in the Treatise on Invertebrate Paleontology has made the search for an existing family to which *Elicrinus* might belong an easier task. Moore, Lane and Strimple (1978), however, referred *Elicrinus* to "Superfamily and Family UNCERTAIN". Within the Suborder Cyathocrinina *Codiocrinus* as defined above (i.e., as defined by Moore, Lane and Strimple 1978) will accept *Elicrinus* without any alteration to its diagnosis at all. In fact it is difficult to separate *C. granulatus* from *E. ornatus* Prokop 1973 which occurs in the Zlichov Limestone in Czechoslovakia except by the transverse ridge on the radial articulatory facet of the latter. Even the plate ornament of granules and ridges appears identical.

Species referred to *Codiocrinus* have been more globose than those referred to *Elicrinus* but *E. ornatus* begins to approach the globosity of *C. granulatus*. The slight variations in cup shape or in cup plate shape cannot be considered generically significant and the two genera should be considered synonymous. The species described below fits the generic concept in every respect.

*Codiocrinus rarus* sp. nov.

Fig. 9E, F

ETYMOLOGY: From the Latin *rarus* meaning rare.

MATERIAL: Only the holotype, NMVP73810, is known and it comes from NMVPL260.

DIAGNOSIS: Member of *Codiocrinus* with smooth calical plates; arms branching isotomously, uniserial non-pinnulate; three primary brachials per arm; stem with serrated outer margins to ossicles, with very short ossicles near cup, abruptly becoming higher away from cup and then with circlet of stout rootlets on each ossicle.

DESCRIPTION: Infrabasals 3, with serrated edge against top of stem, two large and 1 small plate, with obtuse angles at the base of sutures between basal plates, slightly outflared away from stem. Basals quadrangular, with curved lower margin, parallel lateral margins and almost straight upper margin but with broadly obtuse central peak. Radials quadrangular, with straight or slightly curved lower margin, straight lateral margins diverging slightly upwards, with semicircular excavation (i.e. radial facet) occupying approximately half plate width. Radial facet well rounded, sloping outwards, with transverse ridge, and fairly steep sides. First primary brachial completely filling radial facet and continuing outer face of cup. One other primary brachial of same size in each arm before primary axillary which has pentagonal outline viewed from exterior. All cup and arm plates are smooth and unornamented. Stem long, in two distinctly different parts. Proximal part consisting of 18 low ossicles having very strongly serrated sutures between them (i.e. each ossicle with strong crenularia), increasing only slightly in diameter towards cup, without rootlets. Distal part of stem consisting of high ossicles with strong crenularia and a circlet of five short stout spines on each. A few of the higher ossicles near the proximal end of the distal portion do not bear these spines. The distal end of the stem is not preserved.

DISCUSSION: *Codiocrinus rarus* may be distinguished from *C. procerus* (Prokop 1973), *C. ornatus* (Prokop 1973) and *C. granulatus* Schultze 1867 by its lack of granulate and ridge ornament on the cup and by differences in the size and shape of the radial facet. *C. schultzei* Follmann 1887 from the Early Devonian Hunsrück Shale of Germany has a more pronounced globose shape, is a larger form with thin plates and has wider radial facets than *C. rarus*.

The specimen is imperfectly preserved in two areas: 1, in the region of its basal plates which have collapsed inwards but those plates may be reconstructed from the margins of adjacent plates, and 2, in the region of the upper arms where it seems unlikely that there was further branching above the first dichotomy.

Suborder DENDROCRININA Bather 1899

Superfamily DENDROCRINOIDEA Wachsmuth & Springer

1886

Family DENDROCRINIDAE Wachsmuth & Springer 1886

Genus *Dendrocrinus* Hall 1852



TYPE SPECIES (by original designation): *Dendrocrinus longidactylus* Hall, 1852 from the Silurian Rochester Shale at Lockport, New York.

DIAGNOSIS: As given by Moore, Lane and Strimple (1978).

*Dendrocrinus saundersi* sp. nov.

Fig. 7A, B

ETYMOLOGY: This species is named for Mr. Rob Saunders of Melbourne Metropolitan Board of Works who collected the holotype and placed it in the Museum's collection.

MATERIAL: Only the holotype, NMVP74239 is known from beneath the right abutment of the dam.

DIAGNOSIS: Member of *Dendrocrinus* with high, relatively narrow radial plates, narrow horseshoe-shaped radial facets, unornamented thecal plates, anal sac high but relatively slim, anal plates smooth with lateral projections and an occasional spine, very slender arms branching isotomously 3 times and stem long, extremely small in diameter, and with beaded appearance due to irregular diameter and length of nodals.

DESCRIPTION: Crown elongate, narrowly cylindrical, more than 3 times as long as wide; cup relatively small, 6 mm high, conical with diameter less than height; infrabasals visible laterally, high, 0.25 of cup height (approximately), probably 3 in number (non availability of counterpart makes it impossible to count), pentagonal; basals 5 in number, hexagonal, 0.25 of cup height (approximately), centrally bulbous, descending to margin in gently sigmoidal slope; radials large, approximately 0.5 of cup height; C radial not as high as others and broadly quadrangular rather than pentagonal due to presence of radianal plate directly beneath it; anal X large, directly above CD basal from which it is separated by transverse suture, of irregular shape with 7 sides, 1 each against CD basal, C and D radials and radianal and 3 supporting three columns of anal plates; central column of large plates near anal X tapering distally over short distance; anal sac very slender, high (at least half height of arms), consisting of at least 8 columns of smooth quadrangular plates with prominent lateral projections that interlock with plates of adjacent columns; two lateral columns, supported by anal X, of plates of uniform size from base; radial articular facets half width of radial plate, sloping out and down, horseshoe shaped. Arms very narrow, with elongate oval section, branching isotomously three times (18 mm, 36 mm and 76 mm above radial plate on holotype), uniserial, primibrach 5 axillary. Stem very slender, circular in section, consisting of alternating nodals and very low internodals; nodals of variable height and diameter, producing a beaded appearance.

REMARKS ON HOLOTYPE: The counterpart of the holotype was not collected so the anterior of the cup is not available but the posterior provides sufficient information for specific identification. Plates of the cup have collapsed during burial but their outlines are still obvious although the precise shape and number of in-

frabasals plates remains doubtful. Due to the fact that moulds of arms pass into the rock away from the surface of the specimen (in particular ray D) it has proved impossible to obtain satisfactory latex casts of these structures. On withdrawal the latex is stretched beyond recovery or has not penetrated the mould at all. Different casts were obtained from successive applications of latex. The cast of the anal sac which runs up the centre of the specimen is of the posterior side which has collapsed in against the inner anterior side of the sac at the level of the first axillary plate. The inner anterior surface is visible a little further distally before the broken end of the mould of that structure. In this area, on the C ray side of the sac is visible a large spine normal to the plate surface.

REMARKS: As most of the species of *Dendrocrinus* are much in need of revision comparison of the species in hand has proved difficult. However it may be distinguished from all other species of the genus by a combination of its "beaded" stem, smooth thecal plates, slim anal sac and slim thrice-dividing arms.

Future review of the genus may reveal some subdivisions perhaps based on size of cup relative to arms coupled with size and number of columns of plates in anal sac. Until such a review is undertaken in North America *D. saundersi* may reside under this broad generic name.

Class OPHIUROIDEA Gray 1840

Order OEGOPHIURIDA Matsumoto 1915

Suborder LYSOPHIURINA Gregory 1896

Family ENCRINASTERIDAE Schuchert 1914

Subfamily ENCRINASTERINAE Schuchert 1914

Genus *Urosoma* Spencer 1930

*Urosoma glabridiscus* Talent 1965

Fig. 10A, B

1965 *Urosoma glabridiscus* Talent, p. 18, pl. 4, figs 4, 5, pl. 5, fig. 3, pl. 6, figs 2, 4, pl. 7, figs 1, 2, 5, 6, pl. 8, figs 3, 7, pl. 9, figs 2, 5.

HOLOTYPE: GSV 38103 from the Dargile Formation near Heathcote (Loc. 41, Parish of Heathcote, of Talent 1965), of Late Silurian age.

MATERIAL AVAILABLE: One external mould of the aboral surface, NMVP74243, and one external mould of the oral surface, NMVP74240, from beneath the right abutment of the dam.

DISCUSSION: These specimens agree with Talent's (1965) description of the species in every observable respect except that the Sugarloaf specimen has shorter ambulacrals near the mouth frame than near midlength of arm, the arms taper strongly distally and the abradial margins of the ambulacrals are weakly convex. The oral surface is not well enough preserved to see fine details of plates but the general organization is the same as in the Heathcote material. These specimens do not add



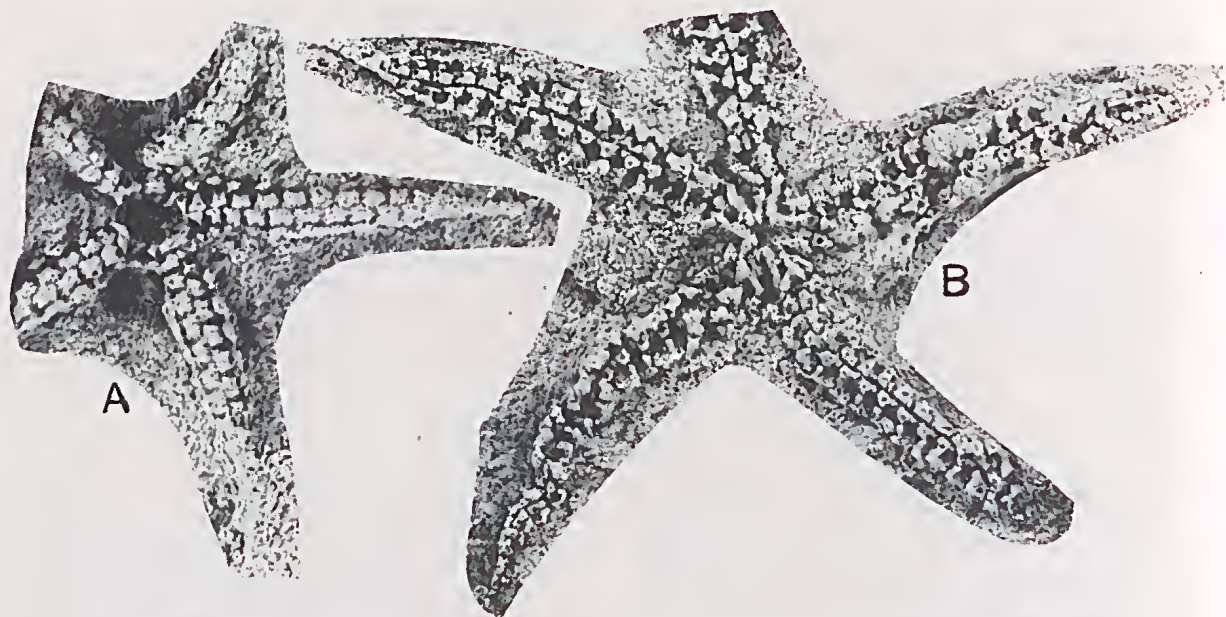


Fig. 10—*Urosoma glabridiscus* Talent 1965. A, aboral view of latex cast, NMVP74243,  $\times 7$ . B, C, oral views of latex cast of NMVP74240,  $\times 4.5$  and  $\times 7$ , respectively.

anything to Talent's (1965) description and discussion of related taxa.

Subfamily ARMATHYRASTERINAE Harper & Morris 1978

Genus *Mausoleaster* nov.

ETYMOLOGY: From the Latin *mausoleum*, a term for a magnificent tomb that derived from that erected for Mausolus at Halicarnassus. It refers to the enormous mausoleum—the Sugarloaf Dam—built over this fossil

site. The suffix *aster* is Latin for star. Gender is masculine.

TYPE SPECIES: *Mausoleaster sugarloafensis* sp. nov.

DIAGNOSIS: Armathyrasterin without disc or marginal frame; with very heavy plates in mouth frame almost identical with those of *Lapworthura*; with very large podial basins on ambulacral plates; with pinnular adambulacral plates having large, possibly spinose adradial expansion; and with adambulacral plates only in contact adradially.

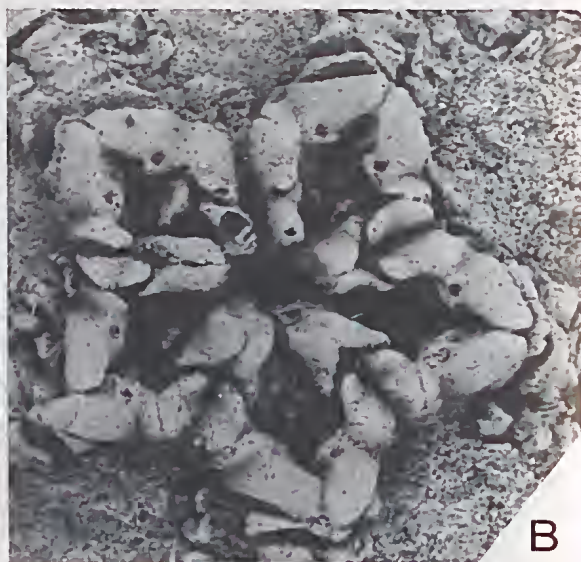


Fig. 11—*Mausoleaster sugarloafensis* sp. nov. NMVP74242. A, aboral view of latex cast,  $\times 4$ . B, enlargement of aboral view of mouth frame of same specimen,  $\times 9$ .



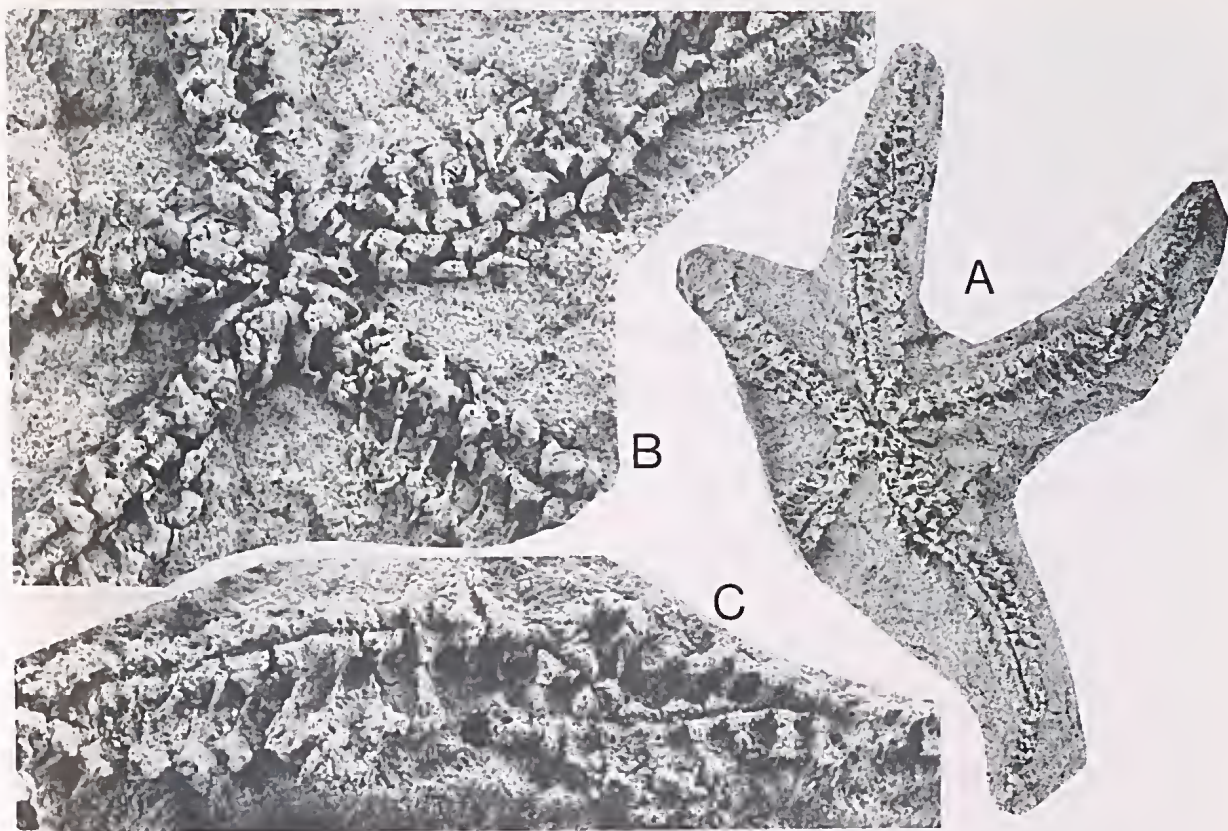


Fig. 12—*Mausoleaster sugarloafensis* sp. nov. A, B, oral views of latex cast of NMVP74241,  $\times 3$  and  $\times 5$  respectively. C, enlargement of part of one arm of NMVP74241,  $\times 7$ .

DISCUSSION: The arm plates in *Mausoleaster* are not as well preserved as in *Armathyrastra* Harper & Morris from the Upper Carboniferous of Pennsylvania, which is the only other genus of the subfamily, but there is sufficient detail to be certain of their structural alliance.

Harper and Morris (1978) suggested that *Armathyrastra* "appears to represent an end product of this (*Encrinaster*) lineage" but pinnular adambulacra in the Siluro-Devonian *Mausoleaster* suggest the possibility of the two subfamilies existing as separate lineages from the Silurian to the Carboniferous. Moreover, the *Armathyrastrinae* could have been the primitive subfamily with its very large podial basins accommodated solely by the ambulacral plates and its pinnular adambulacra. The *Encrinasterinae* with reduced podial basins and more solid adambulacra appear more advanced and could have evolved from an early *armathyrastrin*. With only the two genera of *armathyrastrins* known it seems premature to speculate on their origin but at least a more logical alternative to that proposed by Harper and Morris (1978) now presents itself.

*Mausoleaster* differs from *Armathyrastra* in the shape of the adradial part of the adambulacra, the much more robust mouth frame, lack of interradial disc and some minor differences in shape of ambulacra.

#### *Mausoleaster sugarloafensis* sp. nov.

Figs 11, 12

MATERIAL: The holotype, NMVP74242 from NMVPL 260 is an external mould of the aboral surface. The paratype, NMVP74241 from beneath the right abutment of the dam, is an external mould of the oral surface.

DIAGNOSIS: As for genus.

DESCRIPTION: Five arms, evenly spaced; interradial disc absent.

Mouth frame 5-6 mm in diameter, consisting of large robust plates; first ambulacra much longer in the adradial direction than other ambulacra, becoming wider away from perradial line and crossed near the adradial end by a prominent furrow running obliquely out of the adradial line over two small pits (or apertures) and across the plate; first ambulacra and mouth angle plates abut along a flat face normal to long dimension of both plates; mouth angle plates project into pentagon formed by first ambulacra in pairs at midlength of each side, are crossed obliquely by a very deep furrow near their midlength, rise up steeply adaxial to this furrow and then finish with a high vertical flat face; adaxial ends of the mouth angle plates are almost as high as the distal ends of the first ambulacra which are the highest points



of the mouth frame. A much shallower broader furrow crosses the mouth angle plates, predominantly on their abradial and aboral sides, parallel to the deep furrow and halfway between it and the suture with the first ambulacral. In one interradius a very small elongate plate may represent an odontophore. On the oral side, mouth angle plates are elongate and blade like but with a slightly expanded, vertical, flat to weakly concave oral end. They are in contact at both ends but not in their middle section. No details of the plates of the mouth frame are available on the one specimen available.

Arms are rather wide, petaloid, up to 24 mm long and 4.5 mm wide on NMVP 74241; ambulacrals are not fused, are large, subquadrate, alternating with a weakly concave lateral margin, and supporting the large podial basins distally on the adradial side. Orally the ambulacrals are boot-shaped as is characteristic of the family; the podial basin is prominent on the posterior of the plate and a furrow runs across the plate from the basin. Many ambulacrals show oral or ventral processes at both proximal and distal ends. An adradial projection close to the proximal end of the ambulacral plate joins with a flat sutural junction onto the perradial end of the pinnular adambulacral; adradial plates expanded at their outer end into a large club-shaped structure that extends distally and touches the expanded end of the next adambulacral. This expansion has numerous projections and a vertical furrow at its midlength. Because of the disorientation of many adambulacrals the actual orientation of most of these processes is not clear. Some plate fragments adjacent to adambulacrals may be spines but they may also be dislodged pinnular fragments of the adambulacrals and lateral spines were probably not present. The pinnular part although very thin in dorsal or ventral view had some considerable height so that it was more a flat lath than a rod. The adambulacrals have twisted over onto the ambulacrals in several arms but have still retained the sutural contact so there must have been considerable flexibility in this junction. Distally on the arms where the pinnular part is very short no details are available.

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